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(54) Arc Vaporization Device

(57) In an arc vaporization device, current is supplied to the target (4) via a magnetic coil (6), which serves to establish a full-perimeter pathway for the arc spot on the target surface. The magnetic field generated by this magnetic coil (6) does not exceed a level of 10^{-3} T. As a result of this, during its movement around the periphery the arc spot also executes a radial back and forth wobbling movement, allowing it to reach larger areas of the target surface. The low magnetization level also contributes to an increase in the target yield and a reduction in the droplet count.

The following data are taken from documents submitted by the applicant.

Description

The invention relates to an arc vaporization device for vaporizing a target that is adjacent to a cathode by means of at least one arc spot generated via an arc current from a current source, wherein said device comprises a magnetic coil for guiding and moving the arc spot along the target surface by means of an outer magnetic field, and in said device the target extends into a vacuum chamber that is connected to the anode.

Arc vaporization devices of this type are described, for example, in US-A-4,512,867 or DE-C-35 28 677. Each of these known devices contains a generator for producing the arc current and a generator for supplying current to the magnetic coil. With a high magnetic field intensity on a magnitude of 10^{-2} Tesla, the arc spot, as a result of the Hall Effect, will move along a precisely defined pathway, rather than along a randomly produced, completely irregular pathway, as in the case of the "random arc" process, with said defined pathway being ordinarily defined by two straight lines connected to one another by a semicircle. The process that results from the two above-named devices is thus also referred to as the "steered arc" method.

The main advantage the "steered arc" method has over the "random arc" method is that, primarily due to a greater speed of the arc spot, less target material reaches the vacuum chamber in the undesirable form of droplets, rather than as steam. Such droplets form an undesirable, irregular, and rough surface on the substrate to be coated. However, with the "steered arc" method the advantage of the low droplet count is gained at the price of a substantially lower target yield, due to the fact that the arc spot moves along a precisely defined pathway over the target surface, and as a result of the arc spot's high magnetic field, a groove that is very acutely angled and v-shaped in its cross section is created in the target surface.

The object of the invention is to design an arc vaporization device of the type described at the beginning such that with the lowest possible droplet count a high target yield can be achieved.

This object is attained in accordance with the invention via means for adjusting the outer magnetic field (B_s) to the current value of the intrinsic magnetic field of the arc current (B_i), thereby keeping the field intensity of the outer magnetic field from exceeding a value of 10^{-3} T.

With this magnetic field, which is substantially lower than that of the "steered arc" method, the arc spot is guided less fixedly along a precisely defined pathway. Tests have shown that during its peripheral motion, it executes a continuous radial oscillating motion. Thus it travels along a wobble curve. In this manner a substantially greater surface of the target is reached by the arc spot, therefore the target yield is higher than with the "steered arc" process. Because the field intensity of the outer field is lower than with the current state of the art, rather than creating a v-shaped groove, the arc spot produces a channel in the target surface that is trough-shaped in its cross section, which also increases the target yield.

The device specified in the invention is very simple to control, as it is necessary only to ensure that the intrinsic magnetic field of the arc is equal to the outer magnetic field. If the intrinsic magnetic field should increase as a result of an increase in the current, it is necessary only to ensure via simple means that the outer magnetic field increases correspondingly.

The arc vaporization device is especially simple in design if, in accordance with a further improvement on the invention, the cathode of the current source is connected to the target via the magnetic coil. In this type of device no correcting elements or control systems for the magnetic coil are required, as a changing arc current necessarily changes the outer magnetic field the same amount as the intrinsic magnetic field of the arc. Thus a self-regulating effect is created. An embodiment of this type is also highly cost-effective, since no additional generator with a control system is needed for the magnetic coil. Furthermore, the output of the vaporizer is stabilized by the inductivity of the magnetic coil. Plasma formation also increases considerably, thus improving the process conditions for etching and subsequent coating.

An even greater target yield can be achieved when the magnetic coil is designed to be mechanically shifted crosswise relative to the plane of the target.

A destruction of insulators by the arc spot as it moves away from the end surface of the target can be prevented in a simple manner by providing a peripheral groove along the edge area of the cathode surface, in which a shielding, which is made of an electrically conductive material and does not come into contact with the cathode surface, engages and which is connected to the anode via an RC element. A shielding of this type is able to quickly absorb the charge from the arc that reaches it, resulting in a quenching of the arc.

Ignition of the arc spot can be achieved through simple means with the provision of an ignition finger that is connected to the anode via an ohmic resistor. With the ohmic resistor the full arc current does not flow through the ignition finger when it comes into contact with the target, which would result in caking.

If high vaporization performance is required for the simultaneous coating of multiple substrates, then in accordance with another further improvement on the invention, the target can be designed as a tubular component with a magnetic coil that can be mechanically rotated inside it, and the substrate to be coated can be arranged in a ring around the tubular component.

Optimal exploitation of the target material can be achieved if, in accordance with another embodiment of the invention, the target is a mechanically rotated tubular component that encloses a stationary magnetic coil.

With such a tubular target as well, an effective and simple shielding can be provided by including a peripheral groove in the outer circumferential surface of the tubular component that forms the target, into which groove the shielding engages from the end surfaces of the tubular component.

A DC power source is customarily used as the current source. If the temperature of the substrate must be kept at a low level, then a different further improvement on the invention in which the current source is a unipolar, pulsed current source becomes advantageous.

The invention allows numerous embodiments. In order to provide further clarification, four of these are schematically illustrated in the drawings, and will be described below. The drawings show in

Fig. 1 a cross section of an arc vaporization device in accordance with the invention,

Fig. 2 an area of the device that has been altered relative to that of **Fig. 1**,

Fig. 3 a plan view of the target pursuant to **Fig. 1** and **2**,

Fig. 4 a cross section of a further embodiment of an arc vaporization device according to the invention,

Fig. 5 a cross section of a fourth embodiment of the invention.

Fig. 1 shows a vacuum chamber **1**, the housing **2** of which is connected to the anode of a current source **3** designed as a DC generator. It is also possible, however, for a unipolar, pulsed current to be used. Into the housing **2** from one side a target **4** extends, which is comprised of the material to be vaporized in the device, for example titanium, and which rests on a water-cooled plate **5**.

A magnetic coil **6** is positioned on the outside of the plate **5** and is connected at one end to the cathode of the current source **3** and at the other end to the plate **5**, and thereby also to the target **4**.

Schematically represented inside the vacuum chamber **1** is an ignition finger **7**, which is connected via an ohmic resistor **8** to the anode of the current source **3**. Also illustrated is a shielding **9** made of an electrically conductive material, which engages in a groove **10** that extends around the perimeter of the target **4** near its edge, but does not come into contact with the target **4**, and is connected via an RC element **11** to the housing **2** and thereby to the positive terminal.

In the vacuum chamber **1**, substrates **12** to be coated are held on a rotary platform **13** that is positioned inside the vacuum chamber **1** opposite the target **4**.

During the coating process, the arc current flows first through the magnetic coil **6**, thereby generating an outer magnetic field. This should not exceed a value of 10^{-3} T. In this manner the arc spot will be relatively weakly guided. It moves along a full-perimeter pathway **14** shown in **Fig. 3**, over the surface of the target **4**. During its movement around the perimeter the arc spot executes at the same time an oscillatory or wobble movement in a radial direction, so that it reaches a broad area of the target **4**.

If it is desirable to further increase the target yield, then, as is illustrated schematically in **Fig. 2**, the magnetic coil **6** can be shifted back and forth relative to the target **4** in the direction of the arrow **15**. To make this possible the magnetic coil **6** must be connected via a flexible coupling **16** to the plate **5**. A line **17** leading from the current source **3** to the magnetic coil would already have sufficient flexibility to enable this movement.

In the embodiment shown in **Fig. 4**, the target **4** is designed as a tubular component **18**. The magnetic coil **6** is positioned inside this tubular component **18** such that it can rotate. The rear side of the magnetic coil **6** is covered by a shielding **25** made of soft iron. As before, the cathode of the current source **3** is connected to the magnetic coil **6** for a supply of current, wherein this connection is accomplished via a rotating shaft **19**, which bears the magnetic coil **6**. Current flows from the magnetic coil **6** through a sliding contact **20** to the tubular component **18** that forms the target **4**. For cooling the tubular component **18**, the tubular component **18** [sic] is equipped with a water supply line **21** and a water removal line **22**. An ignition finger **7** serves to ignite the arc in precisely the same manner as with the previously described embodiment.

To confine the arc spot on the circumferential surface of the tubular component **18**, a peripheral groove **10, 10a** is provided near each of the two end surfaces of said component, in which groove the shielding **9, 9a** engages in a manner comparable with the embodiment shown in **Fig. 1**; as before, said shielding is comprised of electrically

conductive material and is connected via an RC element to the anode of the current source **3**.

In the embodiment shown in **Fig. 5,** the target **4** is again designed as a tubular component **18**. In contrast to **Fig. 4**, however, this component is rotatably arranged inside the housing **2** of the vacuum chamber **1**. The magnetic coil **6** is stationary inside the tubular component **18**, so that during operation the tubular component **18** can rotate around the magnetic coil **6**. **Fig. 5** indicates schematically how the supply of current travels from the current source **3** through a shaft **23** that bears and drives the tubular component **18,** to the magnetic coil **6**, and from there via a sliding contact **24** to the tubular component **18**. The anode once again is connected to the housing **2**. The substrates **12** in this embodiment are naturally arranged on only one side of the magnetic coil **6**, or pass by along one side.

Legend

1	Vacuum Chamber
2	Housing
3	Current Source
4	Target
5	Plate
6	Magnetic Coil
7	Ignition Finger
8	Resistor
9	Shielding
10	Groove
11	RC Element
12	Substrate
13	Rotating Platform
14	Pathway
15	Arrow
16	Coupling
17	Line
18	Tubular Component
19	Shaft
20	Sliding Contact
21	Water Supply Line
22	Water Removal Line
23	Shaft
24	Sliding Contact
25	Shielding

Patent Claims

1. Arc vaporization device for vaporizing a target that is adjacent to a cathode by means of at least one arc spot generated via an arc current from a current source, wherein said device has a magnetic coil for the purpose of guiding and moving the arc spot along the

target surface by means of an outer magnetic field, and wherein in said device the target extends into a vacuum chamber that is connected to the anode, **characterized by** means of adjusting the outer magnetic field (B_s) to the current value of the intrinsic magnetic field of the arc current (B_i), and thereby by the condition that the field intensity of the outer magnetic field will not exceed a value of 10^{-3} T.

2. Arc vaporization device in accordance with claim 1, characterized in that the cathode of the current source **(3)** is connected to the target **(4)** via the magnetic coil **(6)**.
3. Arc vaporization device in accordance with at least one of the preceding claims, characterized in that the magnetic coil **(6)** is designed to be mechanically shifted crosswise relative to the plane of the target **(4)**.
4. Arc vaporization device in accordance with at least one of the preceding claims, characterized in that a peripheral groove **(10)** is provided in the edge area of the cathode surface, into which a shielding **(9)** made of an electrically conductive material engages without coming into contact with the cathode surface and is connected to the anode via an RC element **(11)**.
5. Arc vaporization device in accordance with at least one of the preceding claims, characterized in that an ignition finger **(7)** that is connected to the anode via an ohmic resistor **(8)** is provided for igniting the arc spot.
6. Arc vaporization device in accordance with at least one of the preceding claims, characterized in that the target **(4)** is a tubular component **(18)** with a magnetic coil **(6)** that can be mechanically rotated inside said component, and the substrates **(12, 12a)** to be coated are arranged in a ring shape around the tubular component **(18)**.
7. Arc vaporization device in accordance with claim 6, characterized in that the target is a mechanically rotatable tubular component **(18)** that encloses a stationary magnetic coil **(6)**.
8. Arc vaporization device in accordance with claims 6 or 7, characterized in that in each case a peripheral groove **(10, 10a)** is provided in the outer circumferential surface of the tubular component **(18)** that forms the target **(4)**, into which groove the shielding **(9, 9a)** engages from the end surfaces of the tubular component **(18)**.
9. Arc vaporization device in accordance with at least one of the preceding claims, characterized in that the current source **(3)** is a unipolar, pulsed current source **(3)**.

4 pages of drawings attached